Technical Report 444

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THE MODULAR APPROACH (WITH STRATEGIES) TO LEARNING MOTOR SKILLS

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PERSONNEL AND TRAINING RESEARCH LABORATORY

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Instructors and researchers increasingly view the individual as an active
participant in the process of learning. That is, rather than responding
passively to environmental cues, learners can influence the way knowledge and
skills are acquired. Thus, learning should be facilitated if a learner
develops appropriate cognitive strategies or particular mental operations.
Literature on verbal and psychomotor learning supports this contention.
Further, appropriate individualized instruction may provide more efficient over

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learning than conventional group instruction. Self-contained (modular)
instructional packages could be designed to teach not only a desired skill but
a variety of learning strategies that would aid in acquiring the desired skill
and would generalize to aid in acquiring other skills.

A set of modules was developed for self-instruction in the complex gross
motor skill of juggling; a sample module is presented. Related research has
indicated that the group of high school students who were given this modular
instruction with learning strategies performed markedly better than students
who received conventional classroom instruction without learning strategies.

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THE MODULAR APPROACH (WITH STRATEGIES) TO LEARNING MOTOR SKILLS

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FOREWORD

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The Personnel and Training Research Laboratory of the Army Research
Institute for the Behavioral and Social Sciences (ARI) conducts research to
support training methods to optimize skill acquisition and retention. A
variety of research is being conducted on the effects of various learning
strategies on skill acquisiton and retention. ARI, in cooperation with the
Defense Advanced Research Projects Agency (DARPA), is especially interested
in training strategies for acquisition, retention, and transfer of motor
skills. This report reviews possible strategies for learning motor skills
and presents a sample module. One of several reports for which research was
conducted at Florida State University under contract MDA903-77-C-0200, it
was monitored by Joseph S. Ward of ARI under Army Project 2Q161102B74F and
funded by DARPA.

JOSEPH ZELDNER
Technical Director

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THE MODULAR APPROACH (WITH STRATEGIES) TO LEARNING MOTOR SKILLS

BRIEF

Requirement:

To develop and apply a self-contained (modular) written self-instructional package that also teaches learning strategies, for teaching a complex gross motor skill. The purpose was to learn more about the potential effectiveness of modules and strategies in teaching motor skills in varied settings and without a live instructor.

Construction of a Module:

First, the specific skill to be taught, the intended learners, and their prerequisite abilities were determined. Next, an instructional analysis identified the subskills needed. Each subskill was diagrammed into a sequence of intellectual and psychomotor learning. Ten male high-school students tried out the module and provided feedback during construction. The specific skill taught was how to juggle three items at once.

The completed module contains preinstruction information—motivation, definitions of terms, and directions that include proper use of learning strategies—and 25 subskills. Each subskill section describes the subskill to be learned, describes the correct motion sequence and may illustrate it with stick figures, suggests learning strategies to use during practice, provides opportunity to practice until the subskill is sufficiently mastered, and finally tests the mastery. A sample, for Subskill 18, is presented in full in this report.

Related research reported that the group of high-school students given the modular instruction with strategies performed markedly better than other students given classroom instruction without strategies.

Utilization:

The ability to learn motor skills, independent of the presence of an instructor, would benefit not only students and teachers but also military trainees and instructors. Learners would be able to acquire skills when they are best prepared physically and best motivated. Instructors could devote more time to advanced training and skill development while the novice is learning prerequisite or elementary skills. Conversely, persons who already possess primary skills could use a self-instructional module to develop more advanced skills. The Army is developing an extended repertoire of content-oriented training modules; a variety of strategies is presented here for learning physical skills as well.

CONTENTS

INTRODUCTION

The notion that learners of motor skills are active participants in
the learning process, as opposed to passive recipients of information,
has received considerable support in recent years. They respond to
situational cues in their own manner, to enhance the acquisition,
retention, and retrieval of information. It has been postulated that
the development of appropriate cognitive strategies, or particular
mental operations by the learner, should facilitate this "active"
response to stimuli.

Strategies can be defined as learner-directed behaviors which act
upon or manipulate information in an effort to enhance the acquisition,
long-term retention, or subsequent retrieval of intended behaviors. One
factor that may be related to the success of strategies in the learning
process is the mode by which information is presented to the student.

Approaches to instruction can take different forms. The traditional
method is teacher-centered, in which information is transmitted verbally
or in standard textbook form. However, another approach that is used
less often but may be of greater benefit in meeting a variety of in-
dividual needs in education is that of modular instruction. This latter
method is characterized by the dissemination of information in written
form and is self-instructional (student-centered) in nature (Dick &
Carey, 1978). Thus, the former occurs most often in a group setting
whereas the latter is experienced usually in isolation from others. In
view of the problem in most educational and training situations in which
one instructor is asked to meet the unique needs of a multitude of

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students or trainees almost simultaneously in a given period of instruction, it would be of interest to compare modular and traditional instructional methods in terms of their effectiveness when learner strategies are used during the process of motor-skill acquisition and retention. In addition, to determine the potential wisdom of teaching strategies to students and trainees to facilitate the learning and retention of motor skills, it is necessary to understand the cognitive approach to learning.

The Cognitive Approach to Learning

The importance of strategies in the learning and performance of motor skills is predicated on two assumptions. First, as was asserted earlier, it is generally acknowledged by cognitivists that strategies can be controlled by the learner. The ability to organize and supply meaning to information in order to enhance the storage and retreival of it reflects cognitive operations that are performed. In the psychomotor domain, it is becoming more apparent that cognitive processes and strategies are much more involved in skill acquisition and retention than heretofore realized (Singer, 1978).

The second assumption is that the use of strategies should enhance the learning and performance of psychomotor tasks as compared to situations in which no strategies or inappropriate strategies are used (Singer & Gerson, in press). Albeit on scant evidence, certain strategies in the motor learning literature have shown promising results in terms of their positive effect on the learning of particular tasks (Anshel, Notes 1 & 2; Hagenbeck, Note 3; Shea, 1977). Further, the relatively voluminous amount of verbal learning documentation includes virtually unequivocal

support for the use of certain strategies to enhance learning and retention (Klatzky, 1975; Weinstein, 1978).

Despite claims by some motor and verbal learning researchers that their respective disciplines interact minimally and experimental results have little application in the other domain, others reflect a contrary view. Adams contends that "motor behavior is draped with more cognitive activity than most are willing to admit" (p. 89). These cognitions "operate sequentially and serially to help produce skilled movement performance" (Singer, 1978, p. 80). This is "especially true at the beginning stages of learning motor skills" (Singer, 1978, p. 87). Adams (1976) has explained this sequential process in the following manner: "Motor behavior is guided by covert verbal behavior in the early stages of learning...where they (learners) form hypotheses and plans about the next movement on the basis of knowledge of results which they have just received" (p. 89). Thus, it seems that the processing of verbal information is present across behavioral domains. Further, many processes that underlie a person's use of strategies to enhance the learning of written material appears to be similar in the acquisition of motor skills.

Rationale for Strategy Usage

The primary purpose of using strategies is to influence perception, alter the structure of incoming information, and subsequently, facilitate the immediate retrieval and long-term retention of either written information or motor skills. For instance, learners may initiate certain techniques to enhance: (1) their attention to relevant components of a

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skill (Posner & Snyder, 1975); (2) the organization of incoming information (Bousfield, 1953; Miller, 1956); (3) the formation of data into nonverbal (pictoral) as well as verbal form (Paivio, 1969); (4) meaningfulness to novel stimuli (Marteniuk, 1976); and (5) the attachment of new learnings to old learnings (Gagne, 1977; Singer, 1978).

Singer and Gerson (in press) claim that the appropriate use of learner strategies may be a significant determinant of motor skill acquisition and performance. With respect to movement-oriented behaviors, the immediate effect of strategies is to foster stimulus familiarity and, in turn, to increase precision and timing accuracy. To meet the objective of efficient strategy usage, researchers have attempted to have subjects focus on the principles of a particular learning technique, as opposed to the acquisition of specific content material. This focus has been referred to as rule application (Gagne & White, 1978).

Rules operate to guide the individual's behavior in meeting a host of particular situations. Gagne (1977) contends that, in view of the enormous variety of environmental situations to which human beings sucessfully respond, rules are "quite possibly the major organizing factor...in intellectual function" (p. 129). Thus, when a rule is learned, the individual becomes capable of demonstrating consistent performance for any specific requirement within a general class of behaviors. The use of rules to achieve some goal across a variety of learning situations is a similar objective in strategy usage.

There are two primary objectives with regard to strategies. First, it is important that the learner acquire the skills to implement appro-

priately strategies independent of the instructor. Cognitive strategies serve to guide behavior and, as such, enhance the capability to learn. That is, learners should be provided with the necessary skills to use rules, cues, or other techniques to facilitate the learning and long-term retention of information (Gagné & White, 1978). To most educators, the ultimate outcome of meaningful instruction is to instill in learners the ability to develop their own effective cognitive strategies without external guidance. Thus, methods to enhance the self-production of strategies within a learner can and should be taught.

Second, learners should be provided with techniques to facilitate learning and performance with tasks in a variety of situations. Strategies should be taught to learners with the emphasis on responding to classes of stimuli with classes of responses (Harrow, 1972). Once learners comprehend the nature of, and the rationale for, the use of particular techniques during the learning of one task, they should be capable of self-generating strategies in related future learning environments (Bruner, Goodnow, & Austin, 1956). Some researchers have examined the effectiveness of various learner techniques with respect to the ac-quisition and retention of written information and motor skills.

One such technique has been referred to as chunking. The primary purpose of a chunking strategy is to recode incoming data into larger, perhaps more meaningful, units and, consequently, reduce the amount of information in temporary (short-term) memory storage (Miller, 1956). Chunking has been used effectively to elicit superior recall of auditorially presented (Bower, 1970) and visually presented (Bower & Springston, 1970) letter sequences. Another strategy that has been examined is mental imagery.

One imagery technique that has been studied in the literature is the contrived interaction of stimulus pairs. The use of this strategy consists of subjects creating their own form of interaction of paired stimuli. Yuille and Catchpole (1973; 1974) and Danner and Taylor (1973) found recall on immediate and delayed tests to be superior with users of imagery. This strategy also has been used effectively in the psychomotor area.

Hagenbeck (Note 3) found that subjects who imagined their limb to be the second hand on a large clock (which was visually placed before them) while moving to a criterion location on a limb repositioning task elicited significantly superior performance when compared to other groups in which imagery was not included. Further, recall ability was reliably superior over 5 second and 60 second retention intervals, supporting the use of imagery as a valuable strategy to facilitate retention. Anshel (Notes 1 & 2) also found that imagery, used in combination with other techniques, produced significantly better performance in the learning of three-item juggling as compared to the no-strategy (control) group.

Based on experimental findings, the combined use of strategies has received support by researchers. Rohwer (1970) has suggested that imagery is more effective when verbal tags are applied to, and stored with, the image. Hagenbeck (Note 3) postulated that the effectiveness of an imagery strategy would be improved if the learner could attach verbal tags that are personally meaningful and relevant to the movements of a model of the to-be-performed tasks. Zimmerman and Rosenthal (1974) concluded that modeling, when accompanied by a verbal rule, produces a

significantly higher level of acquisition and retention as compared to the use of either modeling or verbal rules separately.

Examples of other strategies that have been used in conjunction with the acquisition of motor skills or prose include: (1) paraphrasing (Anshel, Notes 1 & 2; Weinstein, 1978), in which the learner transforms and reinterprets verbal material or observed movements into his or her own words; (2) movement in a synchronized or rhythmical pattern (Beisman, 1967; Mikol & Denny, 1955); (3) labeling (Hagenbeck, Note 3, Shea, 1977), in which the learner is provided meaningful verbal labels to help form associations between subcomponents of a novel motor skill; and (4) mnemonics (Bower, 1973; Klatzky, 1975; Norman, 1976), whereby the learner may use one of several techniques which, when accompanied by a rule or system of rules, aid in the storage and retrieval of information.

In order to observe whether learning and retention are being enhanced due to the implementation of these techniques, behaviors of the student, subject, or trainee should be monitored by the educator, researcher, or military instructor. In view of the typical learning environment in education in which a single instructor is responsible for the dissemination of information to a group of learners rather than to individuals, the effective control of strategy usage throughout the skill acquisition process may be minimal. One method which might serve to overcome the above limitations, and thereby facilitate learning and retention processes, is through the use of self-instructional modular techniques.

Instruction typically occurs in a group setting in which students of diverse backgrounds are taught by one teacher. This wide range of

entering skills and knowledge of learners has often resulted in a
failure to meet the needs of gifted as well as lower-skilled persons.
Students might benefit more from individualized, as opposed to group,
instruction. As to individual differences, one approach to learning
would be to provide instruction that is compatible with the knowledge
base and capability of each individual. However, in spite of the usual
large learner population in contrast to the number of instructors
available, individualized instruction with both written material and
motor skills has been implemented rarely. The vehicle which often is
used to carry out an educational process of this nature is a type of
instructional materials commonly referred to as modules.

Rationale for using Modular Instruction

Modular instruction includes the use of a self-contained or self-
instructional unit of instruction "that has an integrated theme, provides
students with information needed to acquire specified knowledge and
skills, and serves as one component of a total curriculum" (Dick &
Carey, 1978, p. 5). The terms individualized, personalized, or behavioral
instruction are synonymous with the use of modules in a learning situation.

There are primarily two reasons as to why learners of motor skills
might benefit from individualized, as opposed to group, instruction.
First, the mastery of fundamentals is particularly important in that
fundamental movement patterns serve as the foundation for more advanced
levels of skill (Locke & Jenson, 1971). Most activities of a relatively
complex nature are learned in a progressive and cumulative manner.

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Thus, it is necessary that learners demonstrate consistently effective performance outcomes in more simple movements from which the production of more advanced skills emanate.

The second advantage of individualized instruction is that students with a wide range of skills and abilities should not, and need not, be compared. In dealing with the heterogeneity of student abilities, each learner is given the material and progresses to a more advanced performance level when he or she is ready (Kulik, Kulik, & Hertzler, 1977). This is usually accomplished through the use of multiple quiz forms (Keller, 1968).

The advantages of modular instruction, a form of individualized instruction, have been adequately summarized by Sherman (in Johnson & Ruskin, 1977). He claims that learning and performance outcomes are maximized if students are

> placed in a position where [they] must
>
> respond, where [they] receive nearly
>
> immediate feedback from [their] efforts,
>
> where [they] may proceed at [their] own
>
> pace, where punishing contingencies are
>
> made minimal, and where [their] individual
>
> work is monitored...as [they] proceed
>
> through a carefully designed sequence
>
> of materials requiring increasingly complex
>
> performance (p. 219).

In a review of the literature, Johnson and Ruskin (1977) report that the frequency with which modular and traditional instructional

methods have been experimentally compared are relatively rare since the early 1970's. Their explanation of this reduction in research in the area is that the use of individualized (modular) instruction has become increasingly accepted, thereby requiring less documentation to support its continued use. The accuracy of this contention notwithstanding, the virtual absence of documentation, with the exception of one recent study (Anshel, Note 2) in which modular instruction has been implemented in the context of learning a motor skill, suggests a need for further research in this area.

Anshel compared the effect of modular versus traditional (live-instructor, group-centered) instruction on the acquisition and long-term retention of a series of relatively complex motor (juggling) skills. Two groups of high school students learned from self-contained written (modular) packages while two other groups were traditionally taught. In addition, one of the two groups that was exposed to modular instruction and one of the two groups that experienced traditional instruction also received a set of strategies which they were taught during eight instructional sessions. The results indicated that the groups in which modules were used performed the series of juggling skills significantly better than traditionally taught groups. Although the module-with-strategies group was not statistically superior to the other groups, mean scores revealed the tendency for this group to perform better than the groups in which traditional instruction and/or no strategies were used. Other research also supports the effectiveness of personalized learning techniques when compared to live (traditional) instruction in the learning of written materials.

The vast majority of these studies show that exam performance in personalized courses is at least as good as, if not better than, conventional courses that teach the same content. Kulik, Kulik and Carmichael (1974) reported that 10 of the 13 studies they reviewed revealed significantly higher performance on the exam scores of students who learned from modular materials than from students in the conventionally taught section. Kulik (1976), in a later review, found that 25 of 31 "methodologically sound" comparison studies were reflective of significantly better performance in favor of the personalized method. Finally, Johnson and Ruskin (1977) report similar successes in various academic disciplines. According to the authors, "nearly all reports have shown superior performance by the personalized instructed students; no reports have shown superior performance by the conventionally taught students" (p. 73). In addition to learning outcomes, the effectiveness of modular instruction also has been compared to traditionally taught courses with respect to retention.

Corey and McMichael (1974) readministered the final exam 10 months after the courses had been completed to introductory psychology students who were taught by either the lecture or modular method. Participants had no advanced knowledge of the retest. Students in the latter group scored almost 10% or one letter grade better than the control students. Similar results were found by Austin and Gilbert (1973) in which retention was measured two months after the course was completed. The researchers found that students who learned under the personalized conditions remembered 15 to 20% more than the lecture-recitation students. In fact, the retention results of Austin and Gilbert represented an

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increase in performance differences between groups. Initial learning measured indicated that personalized learning produced superior performances by 10 to 15% above lecture participants. Thus, individualized (modular) instruction had a greater effect on retention than on immediate acquisition.

In other studies, students who learned written material with personalized instructional techniques when compared to the traditionally taught method have demonstrated superior retention 12 to 15 months later in physics (Moore, Hauck, & Gagné, 1973), 5 to 9 weeks later in mathematics (Lu, 1976), and 2 months subsequent to the completion of instruction in a behavior modification course (Cole, Martin, & Vincent, 1975).

The ability to learn motor skills, independent of the presence of an instructor, might benefit students and teachers, athletes and coaches, or military trainees and instructors. Learners would be able to engage in skill acquisition at a time when they are optimally ready in terms of preparation and motivation. Instructors could devote more time to providing individual assistance. Modular instruction can be used for the acquisition of complex skills in a similar manner as for more elementary skills.

Thus, development of the present module applied to the learning of juggling skills was predicated on the need to learn more about the potential effectiveness of modules and strategies with motor skills, in a variety of settings and in the absence of a live instructor. The structure of the module followed the systems approach model as described by Singer and Dick (1974).

The module consisted of a series of subskills, each of which the subjects were asked to master. Each subskill included two components: instruction and a test of subskill mastery. Learner strategies were inserted in the module immediately following instructional information (a description of the to-be-learned skill) and prior to practice. Strategies were not included in the subskill testing section. As was mentioned earlier, the objective of the module was to learn a series of juggling skills.

CONSTRUCTION OF THE MODULE

To enhance the effectiveness, structure, and content of the module, the materials were reviewed by male students, ages 16 to 18 years. This evaluation occurred in two stages.

First, two male students were randomly chosen to proceed through the module in a one-to-one evaluation procedure. At this time, the students were asked to offer suggestions related to vocabulary, typographical errors, omissions of content, and other deficiencies in the materials that might deter motor skill acquisition.

The second evaluation was of a small-group nature in that eight additional male students reviewed modular materials that were revised from the one-to-one evaluation. Based on the feedback from the eight students, revisions were made and the final module written. A discussion of the construction of the module must begin with the instructional analysis.

Conducting An Instructional Analysis

In the present module, the juggling of three items formed the basic to-be-learned skill. However, the steps that were necessary to create the present module may be generalized to other types of motor skills. There are three basic requirements prior to beginning the module construction process.

The first requirement is that the designer must know what behaviors or skills learners will be able to perform when they complete instruction. In the present situation, subjects were asked to learn and perform a series of five juggling skills, with the acquisition of one skill partly dependent on being able to perform the prior skill or skills.

It is also necessary to understand for whom the instruction is intended in terms of personal characteristics (e.g., age, education level, level of skills in the to-be-learned task, and physical development of the students). Such information should indicate the level of difficulty and nature of the skill(s), vocabulary, and objectives to be included or deleted from the package. In addition, learners for whom the module is intended should process task-relevant primary skills, referred to as entry behaviors (Dick & Carey, 1978) and entry characteristics (Singer & Dick, 1974).

Entry behaviors are specific skills that a student, for whom the instruction is intended, must be able to perform prior to beginning the instructional activity. For example, in order to learn juggling, it was necessary to be able to demonstrate a minimal ability to toss and catch bean-bags. As to entry characteristics, the students had to be free

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from visual, cognitive, and physical handicaps that might interfere with the learning and performing of the tasks.

The second requirement prior to developing the module was conducting an instructional analysis. The analysis consists of identifying the subordinate intellectual and motor skills that are required for the student to achieve the instructional goal (Dick & Carey, 1978; Singer & Dick, 1974). Intellectual skills refer to the ability of a learner to describe or identify certain components of the subskill (e.g., identify the correct flight path of a tossed object in juggling). Motor skills are the actual movement patterns related to the subskills that the learner is expected to finish successfully. The complete and accurate identification of the subskills must be made. In the present module, the sources in this process were: (1) an expert juggler (Rapp, Note 4); and (2) an instructional book on juggling (Carlo, 1974).

After the subskills were identified, each subskill was written on an index card and sequenced in order. To do this, the following questions were asked. What does the student have to already know how to do, so that with a minimal amount of instruction a subtask can be learned? What is it the student must already know how to do, the absence of which would make it impossible to learn the given task? Answers to these questions helped to identify additional subskills that were omitted earlier. With the final performance objective being the ability to juggle three items, making a minimum of five consecutive catches, the correct sequence was diagrammed into subordinate and superordinate skills that included intellectual and psychomotor skills.

The completed module contained pre-instructional information and activities followed by a total of 25 subskills. Each of these segments will be discussed in detail.

Pre-Instructional Activities

Motivation. Students were introduced to the modular instruction with information that would enhance their motivation toward learning to juggle. It is clear that the learning of a motor skill cannot occur unless the student wants to learn (Singer, 1975). Therefore, certain techniques were used to bring about the desire to learn to juggle.

One technique was to show students what they would be able to do when they had completed the module. A skilled juggler demonstrated a series of juggling skills to serve this purpose. The observation of a model prior to instruction was the only time learners received information from an external source (the instructor).

Another motivation technique was to communicate the ease of learning juggling and the benefits of learning the skill. The purpose of this information was to inform the learners that this skill was interesting, enjoyable, and relatively easy to learn. It was hoped that this would facilitate the learners' level of aspiration, an important consideration in learning (Locke & Bryan, 1966; Singer, 1975).

Definitions of terms. Each learner was asked to learn the definitions of nine terms that were used throughout the module. The students were informed that unless they became familiar with each term, part of the instruction would be difficult to interpret. Learners were

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asked to remember the definition of each term and, when they were ready, to attempt the "Definition of Terms Test."

Directions. The learners were provided with a set of instructions on the proper and most efficient use of the module. Directions indicated the correct sequence and the proper use of strategies that accompanied most of the 25 subskills.

Instructional Materials

Each subskill consisted of: (1) a description of the to-be-learned skill; (2) a behavioral objective; (3) a description of the correct sequence, often accompanied with stick figures to illustrate the written description of the movement of the subskill; (4) a list of hints, each consisting of a strategy the learner was advised to use during practice; (5) the opportunity to practice the subskill until certain criteria in performance were attained; and (6) the subskill test.

Description of subskills. Derived directly from the instructional analysis, learners were informed of the performance expectations in each subskill. Stated in behavioral terms, learners were to demonstrate, describe, identify, toss, swing, or catch in their effort to attain mastery of the subskill.

Performance objectives. A performance objective is a detailed description of what students will be able to do when they complete a unit of instruction (Dick & Carey, 1978; Mager, 1975). As suggested by Mager (1975), performance objectives (also referred to as instructional or behavioral objectives) contain three components in terms of how they

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are stated: (1) the observed skill or behavior to be learned; (2) the conditions which will prevail during performance of the task; and (3) the specification of the criteria that will be used to indicate the acceptable level of performance.

Thus, if the subskill, as derived from the instructional analysis, requires the learner to demonstrate the correct holding position of object A held in the preferred hand, the performance objective that accompanies this subskill is:

> Given the ability to demonstrate the correct starting position of the arms and feet, you will be able to hold object A correctly in your preferred hand in the starting position with 100% accuracy.

A performance objective that requires a movement pattern is as follows:

> Given the correct flight path of object A, and the ability to accurately toss object B after object A begins to fall, you will be able to catch object A with the nonpreferred hand about 6 inches from the side of your body, with your elbow bent at an angle of about 90°, and with the catch at about waist level, on a minimum of 3 out of 5 attempts.

Description of the subskill. Immediately following the objective was a list, in sequence, of the components (each movement of the subskill). Also included in this list were one or more suggestions for the learner that served to enhance performance. These suggestions are not to be

confused with learner strategies to which the performer is subsequently exposed. Examples of such suggestions were: (1) to toss object A accurately, because when the first tossed object (object A) is off course, the other tosses and catches will also be inaccurate; (2) keep eyes focused on object A, and when it begins to fall, to toss object B; and (3) to relax and try not to bring arms and shoulders too high as this increases tension.

To enhance the clarity of the written instruction, stick figures usually accompanied one or several of the points.

Use of learner strategies. In order to facilitate the skill acquisition process, learners were asked to use one or more techniques (strategies), based on previous experimentation from which they could benefit. The strategies that were incorporated into the modules and placed prior to the actual practice were: mental imagery, directed attention, rhythmic verbalization, and paraphrasing.

For the imagery strategy, subjects were asked to create a mental picture of the task. They were to imagine drawing the bottom half of a big circle when they swung their arms on the underhanded tosses; to picture in their minds the correct flight pattern of the tossed item; and to relax and think for two minutes about the arm movements they should make during the completion of one juggle. The nature of the imagery strategy was compatible with the particular subskill to be learned. The learners did not receive the same directions on each occasion imagery was used. In addition, they were not asked to utilize the imagery strategy more than one time for each subskill throughout instruction.

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The purpose of the directed attention strategy was to assist learners to focus on the most relevant components of each subskill. Students were asked to focus attention on the first tossed bag as it reached its highest point, and then begins to fall. One very important point for the juggler of three objects was to keep eyes up at the point where the tossed bags were to fall, and to be sure that any bag was tossed to the inside of the falling previously tossed bag. Directed attention also served to prevent students from concentrating on inappropriate movements. After learners acquire the skill of two-bag tossing, they were instructed not to visually track the items until they were caught. Instead, they were told that the catches would become automatic.

A strategy that has received limited recognition in other investigations is that of rhythmic verbalization. The learners were required to attach a word or number to each of a series of movements and overtly verbalize that label in synchronization with the movement throughout the task. The purpose of this strategy was to temporally regulate the sequence of the skill. Students were told that if they had difficulty in matching a verbal cue with each movement, this should indicate that slowing the rate at which the task was being performed would be desirable. This could be done by tossing the bags higher, thereby prolonging the time interval between tosses.

Juggling is defined as the tossing and catching of at least one more object than the number of hands performing the task, as only the use of three more items with two hands or two or more items with one hand constitute juggling activity. Thus, the tossing and catching of two items with two hands in sequence is not juggling. In the

present module, however, it was necessary to learn two-item tossing and catching with two hands as a prerequisite to being able to juggle. During this activity learners were required to overtly verbalize the following: "up-up-catch-catch." Each word accompanied the toss of an item with the preferred hand and then the nonpreferred, and the catch of an item with the nonpreferred hand and then the preferred hand, respectively.

Although it is extremely difficult to synchronize verbal labels to the rapid motor responses that occur in the juggling of three objects with two hands, the use of numbers, vocalized in rhythm to the series of movements, was thought to be an effective strategy. Thus, with the juggling of three items, students were asked to attach a number to each of a series of movements, (e.g., one-and-two-and-three-and-four), verbalized in rapid succession.

A strategy called paraphrasing typically is used to allow individuals to communicate information, derived from novel stimuli, in their own words. The purpose of paraphrasing is to enhance the comprehension of verbal information related to a motor task. In this module, paraphrasing occurred when learners were asked to teach a particular subskill to themselves, to verbalize appropriate information. It was assumed that the process of offering learners the opportunity to communicate new information verbally about that skill might strengthen their comprehension and awareness of the relevant task components.

Incorporated into most of the subskills in the module was a series of hints to the learner in which the use of strategies was communicated. This section was located immediately following the written description

and diagrammed information about the subskill, and prior to physical practice.

An example of strategy usage may be found in subskill 16. The learner is to toss object C (the third item in three-item, two-handed juggling) with the preferred hand immediately before catching object B, releasing it at about chin level, to a height of about one foot above the head so that it can be caught about six inches from the other side of the body in the nonpreferred hand. After being provided with written information, accompanied by stick figures to illustrate the movement sequence, learners were offered the following information:

HINTS: (1) Where should you focus your attention on this task? As usual, your eyes should be UP; you are to be looking to the height of each toss. But you also want to be sure that object C, the third tossed item, is thrown accurately. So, keep your eyes up, and think about getting rid of object C from your preferred hand before you try to catch B with same hand.

(2) Don't forget that this series of tosses has a rhythm to it. Say the following aloud: "Up" (toss object A with the preferred hand) - "Up" (toss object B with the nonpreferred hand) - "Catch" (catch object A in the nonpreferred hand) - "Up" (toss object C with preferred hand). So, it's "up-up-catch-up." In the next subskill, you will be asked to catch object B, but do not worry about that now.

(3) When tossing each object, imagine you are drawing the bottom half of a large circle. In other words, make a long scooping motion with the underhanded, swinging toss. AVOID USING A QUICK, JERKY MOTION.

The strategies of directed attention, rhythmic verbalization, and imagery were utilized in subskill 16. An example of a paraphrasing technique is found in subskill 17 in which the learner was to catch object B with the preferred hand almost immediately after the toss of object C. Then the learners are asked in the HINTS section to teach this skill to themselves. In paraphrasing, the learner is asked to communicate information in his or her own words. Learners were to pretend they were juggling instructors teaching someone how to perform subskill 17. They were told to "Teach this skill to yourself, pretending that you know nothing about performing this skill. Actually talk to yourself about each of the things you need to do in order to perform subskill 17 successfully. Include all of the details in terms of how and where to toss and catch each of the three objects."

The subskill test. Tests that are designed to measure one or more explicit objectives are called criterion-referenced tests. The purpose of a test, offered at the conclusion of each subskill in the module, is to: (a) test and evaluate the student's progress; and (b) provide information about the effectiveness of the materials to the instructor. The test items or, in the present module, the subskill test, should correspond directly with the performance objective of that particular subskill. Thus, the test serves to indicate the successful completion

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(acquisition) of the objective (subskill). The subskill test items were constructed so as to meet the requirements of a criterion-referenced test (i.e., the ability to meet the objective), as opposed to a norm-referenced test (i.e., a comparison of student performance to other students).

A SAMPLE: SUBSKILL 18

A sample unit is presented here. It indicates the presentation of directions for the learning of a specific skill, as well as appropriate strategies to enhance the learning of the skill. Similar procedures were used with the other skills.

Objective

Given the correct flight path of object C, which is tossed from the preferred hand, and the catching of object A in the nonpreferred hand and object B in the preferred hand, you will be able to catch object C in the nonpreferred hand at about waist level. You should be able to perform this skill accurately on a minimum of 3 out of 5 attempts.

To Learn Subskill 18, Do This:

1. As usual, it's a matter of remembering the basics: (a) be sure the tosses are accurate; (b) the motion of your arms should be in an underarm, swinging movement, going across the front of your body; (c) release each toss at about chin level; (d) toss each item as

soon as the preceding item (bean-bag) starts to fall; (e) tosses
should be aimed to the inside of the falling object; (f) the
location of the catches should be at about waist leavel (palm up).

2. The correct sequence of this subskill (which is one complete
    juggle) is as follows:

    (a) toss object A (preferred hand);

    (b) when object A begins to fall, toss object B (nonpreferred
         hand) to the inside of the falling object A;

    (c) catch object A (nonpreferred hand);

    (d) toss object C (preferred hand) to the inside of the
         falling object B as soon as object B starts to fall;

    (e) catch object B (preferred hand); and

    (f) catch object C (nonpreferred hand)

Compare each point (a - f) with a figure below.

3. Here are a few common problems many learners of juggling have. See
    if you can overcome them.

    (a) The tosses may not be high enough. This causes the
         juggler to think that too many things are happening at
         one time. Throw each bean-bag high enough to give you
         enough time to catch the earlier tosses.

(b) You might find yourself "running after" the bean bags

to catch them. If this happens, the bags are being

released too low. You want to release each bag at about

chin level.

(c) There is a tendency to hold on to the object to be tossed

for too long. Sometimes, the learner never releases the

object from his or her hand. So, don't "freeze" when

it's time to make each toss. "Get rid" of the bean-bag

when it's time.

(d) Don't concentrate too much on making the catches. You

will begin to catch each bean-bag automatically without

even looking at it IF the tosses are accurate.

(e) Often, learners "rush" the series of tosses. Although

you were warned in letter 'c' (above) to "get rid" of the

bean-bags instead of "hanging on" to them, don't move at

the "speed of light" either. Remember the correct

tossing and catching sequence and take your time com-

pleting each task as it comes. So, one juggle is: Toss-

toss-catch-toss-catch-catch. In other words, relax. But

also, concentrate.

PLEASE USE THE HINTS BELOW WHEN PRACTICING SUBSKILL 18

1. Close your eyes and think about subskill 18. You will be

completing one full juggle, making three tosses and three catches.

Think through the whole task. Each part of subskill 18 has already been

described. Simply read it, remember it, and think about doing it (eyes closed) before you physically practice.

2. In performing one juggle (3 tosses and 3 catches), imagine the pattern of the tosses as a figure 8.

3. Pretend you are being asked to teach subskill 18 to a friend. You are the teacher, so talk to yourself as if you are actually giving instruction to someone. You might include: How to toss the bean-bags correctly; when and where you toss each bag; and what is the correct location of catching each bag. Finally, are there any special techniques you could recommend to the learner that would help him or her perform this skill better? Take this hint seriously. Actually talk to yourself, pretending you are teaching subskill 18.

4. Performing one juggle has a certain rhythm to it. It goes like this: "up-up-catch-up-catch-catch."

Object A is tossed ("up") - Object B is tossed ("up")

Object A is caught ("catch") - Object C is tossed ("up")

Object B is caught ("catch") - Object C is caught ("catch")

While practicing this skill, repeat these words aloud and in rhythm.

"UP-UP-CATCH-UP-CATCH-CATCH."

PLEASE ANSWER THE FOLLOWING QUESTIONS IN WRITING BEFORE YOU PRACTICE:

(1) Describe in detail what you are thinking about when you close your eyes and imagine performing subskill 18.

_____

_____

_____

_____

_____

(2) What pattern does the juggle follow? _____

_____

_____

(3) Based on what you already know, teach your friend how to perform one juggle (subskill 18), making three tosses and three catches. What would you say to him or her? List at least eight of the most important points, but state more if you wish.

    (a)

    (b)

(c)

(d)

(e)

(f)

(4) What is the word sequence and the movement that goes with each word when performing subskill 18 (one juggle)?

(a)

(b)

(c)

(d)

(e)

(f)

Please be sure that your answers are complete and correct. Check each one with the information in subskill 18, and make any additions or corrections. Then, practice subskill 18. When you can perform one juggle on 3 of 5 tries, turn the page to the test.

Subskill 18 Test

Catch object C in your nonpreferred hand while holding object A in the same hand after objects A and B have been tossed and caught. Object C should be caught at about waist level with your nonpreferred elbow bent at an angle of about 90°. This skill should be performed correctly a minimum of 3 out of 5 times.

Scoring

<div align="center">(CHECK OFF AFTER EACH TRY)</div>

Attempts	Correct	Incorrect
1	_____	_____
2	_____	_____
3	_____	_____
4	_____	_____
5	_____	_____

<div align="center">I DID IT</div>

If you were able to catch object C after tossing and catching

objects A and B, then you can now perform one juggle. Con-

gratulations! Things will be a bit more challenging for you

in the next subskill. Please turn the page and try it.

You're on your way!

<div align="center">I DIDN'T DO IT</div>

This is the most difficult skill so far. Don't give up. The

more you practice it, the easier it will become. Review the

points in subskill 18 and practice.

<div align="center">CONCLUDING COMMENTS</div>

An absence of literature exists in which strategies and adjunct

questions, incorporated in a self-contained (modular) instructional

package, have been examined. However, based on the premise upon which these factors have been postulated to enhance the processing of information, it appears that their use in combination in a learning situation might significantly improve the performance and retention of motor skills.

Attempts to improve motor skill acquisition have usually been focused on teacher-initiated behaviors which function to alter the nature of a student's interaction with the environment. Changes in practice schedules, the observance of a live model to demonstrate the to-be-learned skill, and the use of film or video-tape, are examples of such instructional techniques. Unfortunately, the degree to which these methods are effective is limited to the immediate teaching environment and, in addition, presuppose similar benefits for all students. Thus, individual differences in the ability to respond to such techniques in a positive manner are ignored.

Individual but appropriate learner strategies may be used in a variety of instructional and performance situations. Learners may use the particular strategy that they find most effective at the most appropriate time and across a variety of situations. Indications in some studies (Anshel, Note 1; Hagenbeck, Note 3; Shea, 1977) are promising in terms of the facilitative effects of pertinent strategies in the learning of motor skills. Despite the fact that these researchers have asked subjects to use specific strategies during the skill acquisition period, as opposed to the learner creating his or her own strategy, these techniques, once mastered by the learner, can be implemented independent of the experimenter or educators in future situations.

The ability to learn motor skills, independent of the presence of an instructor, would benefit students and teachers, athletes and coaches, or military trainees and instructors. Learners would be able to engage in skill acquisition at a time when they are optimally ready in terms of physical preparation and motivation. Educators, military instructors, and coaches could devote more time to advanced training and skill development while the novice is learning prerequisite or elementary skills. Inversely, for persons who already possess primary skills and need to develop more advanced skills, the use of a self-instructional module for the former group appears advantageous. Modular instruction can be used for the acquisition of complex skills in a similar manner as for more elementary skills.

Thus, the development of the present module is predicated on the need to enhance the availability of opportunities to learn motor skills in a variety of settings and in the absence of a live instructor. In view of the apparent absence of a single study in which the effectiveness of strategies, questions, and modular instruction were examined in combination, research in this area certainly appears warranted.

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